PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Assistant Commissioner for Patents
United States Patent and Trademark Office
Box PCT
Washington, D.C.20231
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 07 August 2000 (07.08.00)	
International application No. PCT/GB99/04144	**Applicant's or agent's file reference** 82
International filing date (day/month/year) 14 December 1999 (14.12.99)	**Priority date** (day/month/year) 17 December 1998 (17.12.98)
Applicant HEEKS, Stephen, Karl et al	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

10 July 2000 (10.07.00)

[] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer Zakaria EL KHODARY
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 99/04144

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H01L51/20

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H01L H05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 97 16053 A (ROBERT BOSCH GMBH) 1 May 1997 (1997-05-01)	1,5,6, 10,11, 13,16, 18,19, 21,23, 31,32
Y	the whole document	17
A		2,3
Y	EP 0 740 489 A (PIONEER ELECTRONIC CORP) 30 October 1996 (1996-10-30) page 2, line 25-39	17

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
8 March 2000	15/03/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	van der Linden, J.E.

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Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International Application No
T/GB 99/04144

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 777 280 A (MOTOROLA INC) 4 June 1997 (1997-06-04)	1,5-7, 10,13, 16,18, 23,24, 29-32
A	column 6, line 15 -column 7, line 22	2,25
X	EP 0 741 419 A (MOTOROLA INC) 6 November 1996 (1996-11-06)	1,2,4, 23, 26-28, 31,32
A	column 2, line 34 -column 3, line 53	10
X	PATENT ABSTRACTS OF JAPAN vol. 1995, no. 10, 30 November 1995 (1995-11-30) & JP 07 169567 A (IDEMITSU KOSAN CO LTD), 4 July 1995 (1995-07-04)	1,5,6, 10,13, 31,32
A	abstract	2,3,7, 11,23
X	WO 98 10473 A (CAMBRIDGE DISPLAY TECH) 12 March 1998 (1998-03-12)	1,31,32
A	claims 1,16,64,165	2,3,23
P,X	WO 98 59528 A (FED CORP) 30 December 1998 (1998-12-30)	1,2,5-7, 10,11, 23-25, 29-32
P,A	page 7, line 19 -page 9, line 10 page 11, line 13 -page 13, line 29	13
P,X	WO 99 02277 A (FED CORP) 21 January 1999 (1999-01-21)	1,2,5-7, 23-25, 29-32
P,A	page 6, line 6 -page 9, line 22	10

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 99/04144

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9716053 A	01-05-1997	DE 19603746 A	24-04-1997
EP 0740489 A	30-10-1996	JP 9017574 A	17-01-1997
		DE 69605968 D	10-02-2097
		US 5739635 A	14-04-1998
EP 0777280 A	04-06-1997	US 5686360 A	11-11-1997
		JP 9161967 A	20-06-1997
		US 5757126 A	26-05-1998
EP 0741419 A	06-11-1996	US 5771562 A	30-06-1998
		CN 1139293 A	01-01-1997
		JP 8306955 A	22-11-1996
JP 07169567 A	04-07-1995	NONE	
WO 9810473 A	12-03-1998	CN 1228911 A	15-09-1999
		EP 0925709 A	30-06-1999
		EP 0946993 A	06-10-1999
		WO 9810621 A	12-03-1998
		GB 2333181 A	14-07-1999
		GB 2332094 A	09-06-1999
WO 9859528 A	30-12-1998	US 5920080 A	06-07-1999
WO 9902277 A	21-01-1999	WO 9903087 A	21-01-1999

PATENT COOPERATION TREATY

PCT

REC'D 20 MAR 2001
WIPO PCT

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
CDT 082 PCT		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GB99/04144	14/12/1999	17/12/1998
International Patent Classification (IPC) or national classification and IPC H01L51/20		
Applicant CAMBRIDGE DISPLAY TECHNOLOGY LTD et al		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 12 sheets, including this cover sheet.

 ☐ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

 These annexes consist of a total of sheets.

3. This report contains indications relating to the following items:

 - I ☒ Basis of the report
 - II ☐ Priority
 - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
 - IV ☒ Lack of unity of invention
 - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
 - VI ☐ Certain documents cited
 - VII ☒ Certain defects in the international application
 - VIII ☒ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
10/07/2000	16.03.2001
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Götz, A Telephone No. +49 89 2399 2498

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB99/04144

I. Basis of th report

1. This report has been drawn on the basis of *(substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments (Rules 70.16 and 70.17).)*:
Description, pages:

1-7 as published

Claims, No.:

1-32 as published

Drawings, sheets:

1/2-2/2 as published

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

IV. Lack of unity of invention

1. In response to the invitation to restrict or pay additional fees the applicant has:

☐ restricted the claims.

☐ paid additional fees.

☐ paid additional fees under protest.

☐ neither restricted nor paid additional fees.

2. ☒ This Authority found that the requirement of unity of invention is not complied and chose, according to Rule 68.1, not to invite the applicant to restrict or pay additional fees.

3. This Authority considers that the requirement of unity of invention in accordance with Rules 13.1, 13.2 and 13.3 is

☐ complied with.

☒ not complied with for the following reasons:
see separate sheet

4. Consequently, the following parts of the international application were the subject of international preliminary examination in establishing this report:

☒ all parts.

☐ the parts relating to claims Nos. .

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	4-9, 14-22, 25-28
	No:	Claims	1-3, 10-13, 23, 24, 29-32
Inventive step (IS)	Yes:	Claims	
	No:	Claims	4-9, 14-22, 25-28

Industrial applicability (IA) Yes: Claims 1-32
No: Claims

2. Citations and explanations
see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

1 Reference is made to the following documents:

D1: PATENT ABSTRACTS OF JAPAN vol. 1995, no. 10, 30 November 1995 (1995-11-30) & JP 07-169567 A (IDEMITSU KOSAN CO LTD), 4 July 1995 (1995-07-04) & English language translation
D2: EP-A-0 741 419 (MOTOROLA INC) 6 November 1996 (1996-11-06)
D3: WO 97 16053 A (ROBERT BOSCH GMBH) 1 May 1997 (1997-05-01)
D4: WO 98 10473 A (CAMBRIDGE DISPLAY TECH) 12 March 1998 (1998-03-12).

Re Item IV

Lack of unity of invention

2 The subject-matter of independent claims 1 and 10 is already known (see Item V of the present report). The requisite unity of invention (Rule 13.1 PCT) therefore no longer exists inasmuch as a technical relationship involving one or more of the same or corresponding special technical features in the sense of Rule 13.2 PCT does not exist between the subject-matter of the independent claims 1 and 10.

Re Item V

Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

3 The subject-matter of independent claim 1 of the present application is not new in the sense of Article 33(2) PCT.
D1 discloses (the references in parentheses applying to JP 07-169567 A):
an organic light-emitting device (cf. Fig. 1) comprising a layer of light-emissive organic material (cf. Fig. 1, reference sign 14) interposed between a first electrode (cf. Fig. 1, reference sign 12) and a second electrode (cf. Fig. 1, reference sign 13), at least one of the first and second electrodes comprising one or more electrode layers on the layer of light-emissive organic material for injecting charge carriers into the light-emissive organic material, wherein the organic light-emitting device further comprises a layer of dielectric material (cf. Fig. 1, reference sign 3 and column 14, line 44 - column 15, line 21) on the surface of the outermost electrode layer remote from the layer of light-emissive organic material. Hence all

the technical features of claim 1 are known from D1.

It is noted that the subject-matter of independent claim 1 of the present application is neither new against D2 (cf. Fig. 2 and column 2, line 34 - column 3, line 27).

4 Dependent claims 2-9 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of novelty (Article 33(2) PCT) and/or inventive step (Article 33(3) PCT), the reasons being as follows:

4.1 Claim 2: The subject-matter claim 2 is not new (Article 33(2) PCT). In D1 the dielectric material is AlN, Si_3N_4 or Al_2O_3 (cf. JP 07-169567 A, column 15, lines 12-14). The alternative SiO_2 is disclosed in D2 in combination with all the features of claim 1. The restriction of claim 2 to the alternative SiO could not be considered as involving an inventive step neither (Article 33(3) PCT) since SiO is merely one of several straightforward possibilities from which the skilled person would select.

4.2 Claim 3: The subject-matter of claim 3 is not new (Article 33(2) PCT). In D1 the dielectric material is AlN (cf. JP 07-169567 A, column 15, lines 13-14).

4.3 Claim 4: The thickness range is known from D1 (cf. JP 07-169567 A, column 7, lines 44-45, column 25, lines 1-2 and column 16, lines 31-36) and from D2 (cf. column 3, lines 24-26).

4.4 Claim 5-7: In D1 a second layer of dielectric material on the first layer of dielectric material is disclosed (cf. JP 07-169567 A, Fig. 1 and column 14, lines 37-42 and column 19, lines 20-29). In D1 the second dielectric material may be different from the first dielectric material (cf. English language translation of JP 07-169567 A, page 31, lines 12-23). It is also disclosed that the first and second layers of dielectric material comprise layers of materials selected from the group consisting of AlN, SiO_2, Si_3N_4 and Al_2O_3 (cf. JP 07-169567 A, column 15, lines 12-14 and column 19, lines 20-23).

4.5 Claim 8: Although the specific combination of the first layer being AlN and the second layer being Al_2O_3 is not explicitly mentioned, it is one of the possible

combinations of materials disclosed in D1 (cf. JP 07-169567 A, column 15, lines 12-14 and column 19, lines 20-23). The particular combination of AlN and Al_2O_3 is merely one of several straightforward possibilities from which the skilled person would select, in accordance with circumstances, without the exercise of inventive skill.

4.6 Claim 9: The thickness ranges are similar to the ranges disclosed in D1 (cf. JP 07-169567 A, column 7, lines 44-45, column 25, lines 1-2, column 26, lines 2-3 and column 16, lines 31-36).

5 The subject-matter of independent claim 10 of the present application is not new in the sense of Article 33(2) PCT.
D1 discloses (the references in parentheses applying to JP 07-169567 A):
an organic light emitting device (cf. Fig. 1) comprising at least one layer of a light emissive organic material (cf. Fig. 1, reference sign 14) interposed between a first electrode (cf. Fig. 1, reference sign 12) and a second electrode (cf. Fig. 1, reference sign 13), at least one of the first and second electrodes comprising one or more electrode layers on the light-emissive material for injecting charge carriers into the light-emissive material; wherein the organic light-emitting device further has a stack (cf. Fig. 1, reference signs 3 and 4) comprising a first inert barrier layer (cf. Fig. 1, reference sign 42 and column 19, lines 20-29) and at least one gettering layer (cf. Fig. 1, reference sign 41 and column 19, lines 7-19) interposed between the outermost electrode layer and the first inert barrier layer (cf. Fig. 1) for absorbing moisture and oxygen. Hence all the technical features of claim 10 are known from D1.

It is noted that the subject-matter of independent claim 10 of the present application is neither new against D3 (cf. the single Figure and description thereof and in particular page 8, line 4 - page 9, line 12).

6 Dependent claims 11-22 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of novelty (Article 33(2) PCT) and/or inventive step (Article 33(3) PCT), the reasons being as follows:

6.1 Claim 11: The subject-matter of claim 11 is not new (Article 33(2) PCT). In D1 the dielectric material is AlN, Si_3N_4 or Al_2O_3 (cf. JP 07-169567 A, column 19, lines 20-23 and column 15, lines 12-14). All the materials, including the alternative silicon oxide, are disclosed in D3 (cf. D3, page 8, lines 16-26) in combination with all the features of claim 10.

6.2 Claim 12: The thickness range is known from D1 (cf. JP 07-169567 A, column 7, lines 44-45 and column 25, lines 1-2).

6.3 Claim 13: For the assessment of novelty and inventive step of claim 13 it is supposed that it depends on claim 10 (see Item VII of this communication). In D1 the stack further comprises a second inert barrier layer (cf. JP 07-169567 A, Fig. 1, reference sign 3 and column 14, line 44 - column 15, line 21) interposed between the gettering layer and the surface of the outermost electrode layer remote from the layer of light-emissive organic material (cf. JP 07-169567 A, Fig. 1). It is noted that in D3 the stack also contains a second inert layer (cf. the single Figure, reference sign 34).

6.4 Claim 14: Novelty and inventive step of claim 14 are assessed as far as claim 14 can be understood (cf. Item VIII of this communication). In D1 AlN is one of the explicitly proposed materials for the topmost layer (cf. JP 07-169567 A, column 19, lines 21-23 and column 15, lines 13-14). A sputtered aluminium layer on top of the cathode layer is known from e.g. D4 (cf. page 7, line 31 - page 8, line 6). The skilled person would consider using a protective stack of layers as disclosed in D1 or D2 also on such a known electrode configuration.

6.5 Claim 15: The thickness ranges are similar to the ranges disclosed in D1 (cf. JP 07-169567 A, column 7, lines 44-45, column 25, lines 1-2, column 26, lines 2-3 and column 16, lines 31-36).

6.6 Claim 16: D1 discloses said materials for the gettering layer. (cf. JP 07-169567 A, column 19, lines 7-19 and column 20, lines 24-42).

6.7 Claim 17: A BaO layer as one layer of a protective stack is known from D1 (cf. JP 07-169567 A, column 15, lines 12).

6.8 Claims 18 and 19: The gettering materials Li and Ca are known from D3 (cf. page 8, lines 11-14).

6.9 Claim 20: The thickness range is similar to the range disclosed in D1 (cf. JP 07-169567 A, column 7, lines 44-45 and column 26, line 1).

6.10 Claims 21 and 22: In none of D1 and D3 are multilayer electrodes according to claims 21 and 22 disclosed. It is however common practice in the art of organic light-emitting devices to provide electrodes consisting of al least two layers, wherein one layer has the appropriate work function for charge carrier injection and the other layer provides good electrical conductivity. As an example of such an electrode structure document D4 is cited. On page 17, lines 19-22 a low work function layer of 50 nm of calcium covered by 200 nm of aluminum is disclosed. Hence all the technical features of claims 21 and 22 are known from D4. The skilled person would consider using a protective stack of layers as disclosed in D1 or D2 also on such a known electrode configuration.

7 The subject-matter of claim independent 23 of the present application is not new in the sense of Article 33(2) PCT.
D1 discloses (the references in parentheses applying to JP 07-169567 A):
a method of providing a protective cap on a first electrode of an organic light-emitting device comprising at least one layer of a light-emissive organic material between first and second electrodes for injecting charge carriers into the light-emissive organic material (cf. JP 07-169567 A, the abstract and Fig. 1), said method comprising the step of forming a first layer of a dielectric material (cf. JP 07-169567, Fig. 1, reference sign 3 and column 14, line 49 - column 15, line 1) on the surface of the first electrode opposite the layer of light-emissive organic material by a vacuum evaporation technique (cf. JP 07-169567, column 15, lines 26-35). Hence all the technical features of claim 23 are known from D1.

It is noted that the subject-matter of independent claim 23 of the present application is neither new against D2 (cf. Fig. 2 and column 3, lines 14-27).

8 Dependent claims 24-30 do not contain any features which, in combination with

the features of any claim to which they refer, meet the requirements of the PCT in respect of novelty (Article 33(2) PCT) and/or inventive step (Article 33(3) PCT), the reasons being as follows:

8.1 Claim 24: D1 discloses the step of forming a second layer of dielectric material on the surface of the first layer of dielectric material (cf. JP 07-169567 A, Fig. 2).

8.2 Claim 25: The first layer comprising a layer of silicon monoxide is not explicitly mentioned in none of D1 and D2. However, materials such as AlN, Al_2O_3, Si_3N_4 (D1) and SiO_2 (D2) are disclosed. SiO is just a further often used inorganic dielectric material.

8.3 Claims 26 - 28: The thickness ranges are similar to the range disclosed in D1 (cf. JP 07-169567 A, column 7, lines 44-45).

8.4 Claim 29: Sputtering is one of the methods considered in D1 for the formation of the second layer (cf. JP 07-169567 A, column 19, lines 3-4 and column 15, lines 26-28).

8.5 Claim 30: AlN, Al_2O_3, Si_3N_4 are known from D1 as material of the topmost layer (cf. JP 07-169567 A, column 19, lines 21-23 and column 15, lines 12-14).

9 The subject-matter of claim 31 of the present application is not new in the sense of Article 33(2) PCT. D1 also discloses an organic-light emitting device produced by a method according to claims 23 to 30 (cf. JP 07-169567 A, Fig. 1).

10 A device according to claim 32 is known from e.g. D1 or D2.

Re Item VII

Certain defects in the international application

11 Claim 32 contains a reference to the drawings. According to Rule 6.2(a) PCT, claims may not contain such references.

12 It seems that claim 13 contains a clerical error: it depends on claim 1 but in claim

1 there is no "stack" defined. It is supposed that claim 13 depends on claim 10.

13 The features of the claims are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT).

14 The independent claims are not in the two-part form in accordance with Rule 6.3(b) PCT.

15 The unit of measure "Angstrom" employed in claims 26-28 and on page 7 is not additionally expressed in terms of the units stipulated by Rule 10.1(a) PCT.

16 In the description on page 7 there is a reference to a Figure 7. There is however no Figure 7. Furthermore, contrary to Rule 11.13(l) PCT the reference signs 24 and 26 (page 7, lines 4 and 5) do not appear in any figure.

17 According to the requirements of Rule 11.13(l) reference signs not appearing in the description shall not appear in the drawings, and vice versa. This requirement is not met in view of the reference sign 22 in Figure 6.

18 Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in the documents D1-D4 is not mentioned in the description, nor are these documents identified therein.

Re Item VIII

Certain observations on the international application

19 Claim 5 is not clear (Article 6 PCT) due to the expression "... the thickness of the layers being selected so as to reduce mechanical stress on the cathode.". Firstly, it is not clear compared to which situation the stress is reduced. It seems that additional layers will rather tend to increase mechanical stress. It also seems that thin layers will induce less stress than thick layers, meaning that any of the cited prior art document comprises the feature that the thickness of the layers is selected so as to induce only minor mechanical stress. Secondly, the claim attempts to define the subject-matter in terms of the result to be achieved which merely amounts to a statement of the underlying problem. The technical features

necessary for achieving this result are missing in claim 5.

20 The expression "... the inert barrier layer is a layer of sputtered aluminium ..." renders claim 14 unclear (Article 6 PCT) since aluminium is a reactive metal and not an inert material. Rather than an inert barrier layer such an aluminium layer seems to be a cathode layer providing good electrical conductivity to the cathode.

21 Claim 31 is unclear (Article 6 PCT) since it is not clear what the structural terms defining the device are.

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
82		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/GB 99/ 04144	14/12/1999	17/12/1998
Applicant		
CAMBRIDGE DISPLAY TECHNOLOGY LTD et al		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

 a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

 [] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

 b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

 [] contained in the international application in written form.

 [] filed together with the international application in computer readable form.

 [] furnished subsequently to this Authority in written form.

 [] furnished subsequently to this Authority in computer readble form.

 [] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

 [] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [] **Certain claims were found unsearchable** (See Box I).

3. [] **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,

 [X] the text is approved as submitted by the applicant.

 [] the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

 [X] the text is approved as submitted by the applicant.

 [] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 1

 [X] as suggested by the applicant.

 [] None of the figures.

 [] because the applicant failed to suggest a figure.

 [] because this figure better characterizes the invention.

INTERNATIONAL SEARCH REPORT

International Application No
PC[redacted]B 99/04144

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H01L51/20

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H01L H05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 97 16053 A (ROBERT BOSCH GMBH) 1 May 1997 (1997-05-01)	1,5,6, 10,11, 13,16, 18,19, 21,23, 31,32
Y	the whole document	17
A		2,3

Y	EP 0 740 489 A (PIONEER ELECTRONIC CORP) 30 October 1996 (1996-10-30) page 2, line 25-39	17

	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
8 March 2000	15/03/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	van der Linden, J.E.

1

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International Application No
PC[redacted] 99/04144

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 777 280 A (MOTOROLA INC) 4 June 1997 (1997-06-04)	1,5-7, 10,13, 16,18, 23,24, 29-32
A	column 6, line 15 -column 7, line 22	2,25
X	EP 0 741 419 A (MOTOROLA INC) 6 November 1996 (1996-11-06)	1,2,4, 23, 26-28, 31,32
A	column 2, line 34 -column 3, line 53	10
X	PATENT ABSTRACTS OF JAPAN vol. 1995, no. 10, 30 November 1995 (1995-11-30) & JP 07 169567 A (IDEMITSU KOSAN CO LTD), 4 July 1995 (1995-07-04)	1,5,6, 10,13, 31,32
A	abstract	2,3,7, 11,23
X	WO 98 10473 A (CAMBRIDGE DISPLAY TECH) 12 March 1998 (1998-03-12)	1,31,32
A	claims 1,16,64,165	2,3,23
P,X	WO 98 59528 A (FED CORP) 30 December 1998 (1998-12-30)	1,2,5-7, 10,11, 23-25, 29-32
P,A	page 7, line 19 -page 9, line 10 page 11, line 13 -page 13, line 29	13
P,X	WO 99 02277 A (FED CORP) 21 January 1999 (1999-01-21)	1,2,5-7, 23-25, 29-32
P,A	page 6, line 6 -page 9, line 22	10

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PC[redacted] 99/04144

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9716053 A	01-05-1997	DE 19603746 A	24-04-1997
EP 0740489 A	30-10-1996	JP 9017574 A	17-01-1997
		DE 69605968 D	10-02-2097
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EP 0777280 A	04-06-1997	US 5686360 A	11-11-1997
		JP 9161967 A	20-06-1997
		US 5757126 A	26-05-1998
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		JP 8306955 A	22-11-1996
JP 07169567 A	04-07-1995	NONE	
WO 9810473 A	12-03-1998	CN 1228911 A	15-09-1999
		EP 0925709 A	30-06-1999
		EP 0946993 A	06-10-1999
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		GB 2333181 A	14-07-1999
		GB 2332094 A	09-06-1999
WO 9859528 A	30-12-1998	US 5920080 A	06-07-1999
WO 9902277 A	21-01-1999	WO 9903087 A	21-01-1999

EUROPEAN PATENT OFFICE

Patent Abstracts of Japan

PUBLICATION NUMBER : 07169567
PUBLICATION DATE : 04-07-95

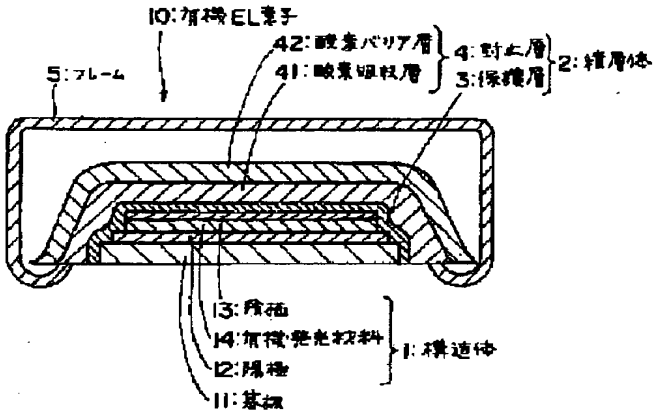
APPLICATION DATE : 16-12-93
APPLICATION NUMBER : 05343635

APPLICANT : IDEMITSU KOSAN CO LTD;

INVENTOR : KAWAMURA HISAYUKI;

INT.CL. : H05B 33/04

TITLE : ORGANIC EL ELEMENT



ABSTRACT : PURPOSE: To prevent the degradation of a light emitting characteristic caused by oxygen or moisture, and maintain a stable light emitting characteristic over a long period of time by arranging a layer of double layers composed of an oxygen barrier layer and an oxygen absorbing layer as a sealing layer of a layered body.

CONSTITUTION: A sealing layer 4 is arranged outside of a structure body 1 as a layered body 2 through a protective layer 3. This sealing layer 4 is composed of one or more sets of double layers by forming an oxygen absorbing layer 41 and an oxygen barrier layer 42 as a single set. An organic compound, an oxygen absorbing compound, a fluorine compound, metallic fine powder and the like having small ionization potential are used as a material used in the oxygen absorbing layer 41. Metallic oxide, nitride, fluoride and the like used as the protective layer 3 are used as the oxygen barrier layer 42.

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BNSDOCID: <JP_407169567A_AJ_>

PATENT COOPERATION TREAT DT 082

From the INTERNATIONAL SEARCHING AUTHORITY

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT OR THE DECLARATION

(PCT Rule 44.1)

To:
CAMBRIDGE DISPLAY TECHNOLOGY LTD,
Green House,
Attn. HARTWELL, I.
Madingley Rise,
Madingley Road,
Cambridge CB3 0HJ
UNITED KINGDOM

Applicant's or agent's file reference 82	Date of mailing *(day/month/year)* 15/03/2000
International application No. PCT/GB 99/04144	FOR FURTHER ACTION See paragraphs 1 and 4 below
Applicant CAMBRIDGE DISPLAY TECHNOLOGY LTD et al	International filing date *(day/month/year)* 14/12/1999

1. [X] The applicant is hereby notified that the International Search Report has been established and is transmitted herewith.

Filing of amendments and statement under Article 19:
The applicant is entitled, if he so wishes, to amend the claims of the International Application (see Rule 46):

When? The time limit for filing such amendments is normally 2 months from the date of transmittal of the International Search Report; however, for more details, see the notes on the accompanying sheet.

Where? Directly to the International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Fascimile No.: (41–22) 740.14.35

For more detailed instructions, see the notes on the accompanying sheet.

2. [] The applicant is hereby notified that no International Search Report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.

3. [] With regard to the protest against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

[] the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

[] no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Further action(s):** The applicant is reminded of the following:

Shortly after 18 months from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in Rules 90*bis*.1 and 90*bis*.3, respectively, before the completion of the technical preparations for international publication.

Within 19 months from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).

Within 20 months from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected in the demand or in a later election within 19 months from the priority date or could not be elected because they are not bound by Chapter II.

Name and mailing address of the International Searching Authority European Patent Office, P.B. 5818 Patentlaan 2 NL–2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax (+31–70) 340–3016	Authorized officer Trudy Thoen-de Jong

Form PCT/ISA/220 (July 1998)

NOTES TO FORM PCT/ISA/220

These Notes are intended to give the basic instructions concerning the filing of amendments under article 19. The Notes are based on the requirements of the Patent Cooperation Treaty, the Regulations and the Administrative Instructions under that Treaty. In case of discrepancy between these Notes and those requirements, the latter are applicable. For more detailed information, see also the PCT Applicant's Guide, a publication of WIPO.

In these Notes, "Article", "Rule", and "Section" refer to the provisions of the PCT, the PCT Regulations and the PCT Administrative Instructions respectively.

INSTRUCTIONS CONCERNING AMENDMENTS UNDER ARTICLE 19

The applicant has, after having received the international search report, one opportunity to amend the claims of the international application. It should however be emphasized that, since all parts of the international application (claims, description and drawings) may be amended during the international preliminary examination procedure, there is usually no need to file amendments of the claims under Article 19 except where, e.g. the applicant wants the latter to be published for the purposes of provisional protection or has another reason for amending the claims before international pbulication. Furthermore, it should be emphasized that provisional protection is available in some States only.

What parts of the international application may be amended?

Under Article 19, only the claims may be amended.

During the international phase, the claims may also be amended (or further amended) under Article 34 before the International Preliminary Examining Authority. The description and drawings may only be amended under Article 34 before the International Examining Authority.

Upon entry into the national phase, all parts of the international application may be amended under Article 28 or, where applicable, Article 41.

When? Within 2 months from the date of transmittal of the international search report or 16 months from the priority date, whichever time limit expires later. It should be noted, however, that the amendments will be considered as having been received on time if they are received by the International Bureau after the expiration of the applicable time limit but before the completion of the technical preparations for international publication (Rule 46.1).

Where not to file the amendments?

The amendments may only be filed with the International Bureau and not with the receiving Office or the International Searching Authority (Rule 46.2).

Where a demand for international preliminary examination has been/is filed, see below.

How? Either by cancelling one or more entire claims, by adding one or more new claims or by amending the text of one or more of the claims as filed.

A replacement sheet must be submitted for each sheet of the claims which, on account of an amendment or amendments, differs from the sheet originally filed.

All the claims appearing on a replacement sheet must be numbered in Arabic numerals. Where a claim is cancelled, no renumbering of the other claims is required. In all cases where claims are renumbered, they must be renumbered consecutively (Administrative Instructions, Section 205(b)).

The amendments must be made in the language in which the international application is to be published.

What documents must/may accompany the amendments?

Letter (Section 205(b)):

The amendments must be submitted with a letter.

The letter will not be published with the international application and the amended claims. It should not be confused with the "Statement under Article 19(1)" (see below, under "Statement under Article 19(1)").

The letter must be in English or French, at the choice of the applicant. However, if the language of the international application is English, the letter must be in English; if the language of the international application is French, the letter must be in French.

The letter must indicate the differences between the claims as filed and the claims as amended. It must, in particular, indicate, in connection with each claim appearing in the international application (it being understood that identical indications concerning several claims may be grouped), whether

(i) the claim is unchanged;

(ii) the claim is cancelled;

(iii) the claim is new;

(iv) the claim replaces one or more claims as filed;

(v) the claim is the result of the division of a claim as filed.

The following examples illustrate the manner in which amendments must be explained in the accompanying letter:

1. [Where originally there were 48 claims and after amendment of some claims there are 51]:
"Claims 1 to 29, 31, 32, 34, 35, 37 to 48 replaced by amended claims bearing the same numbers; claims 30, 33 and 36 unchanged; new claims 49 to 51 added."

2. [Where originally there were 15 claims and after amendment of all claims there are 11]:
"Claims 1 to 15 replaced by amended claims 1 to 11."

3. [Where originally there were 14 claims and the amendments consist in cancelling some claims and in adding new claims]:
"Claims 1 to 6 and 14 unchanged; claims 7 to 13 cancelled; new claims 15, 16 and 17 added." or
"Claims 7 to 13 cancelled; new claims 15, 16 and 17 added; all other claims unchanged."

4. [Where various kinds of amendments are made]:
"Claims 1-10 unchanged; claims 11 to 13, 18 and 19 cancelled; claims 14, 15 and 16 replaced by amended claim 14; claim 17 subdivided into amended claims 15, 16 and 17; new claims 20 and 21 added."

"Statement under article 19(1)" (Rule 46.4)

The amendments may be accompanied by a statement explaining the amendments and indicating any impact that such amendments might have on the description and the drawings (which cannot be amended under Article 19(1)).

The statement will be published with the international application and the amended claims.

It must be in the language in which the international appplication is to be published.

It must be brief, not exceeding 500 words if in English or if translated into English.

It should not be confused with and does not replace the letter indicating the differences between the claims as filed and as amended. It must be filed on a separate sheet and must be identified as such by a heading, preferably by using the words "Statement under Article 19(1)."

It may not contain any disparaging comments on the international search report or the relevance of citations contained in that report. Reference to citations, relevant to a given claim, contained in the international search report may be made only in connection with an amendment of that claim.

Consequence if a demand for international preliminary examination has already been filed

If, at the time of filing any amendments under Article 19, a demand for international preliminary examination has already been submitted, the applicant must preferably, at the same time of filing the amendments with the International Bureau, also file a copy of such amendments with the International Preliminary Examining Authority (see Rule 62.2(a), first sentence).

Consequence with regard to translation of the international application for entry into the national phase

The applicant's attention is drawn to the fact that, where upon entry into the national phase, a translation of the claims as amended under Article 19 may have to be furnished to the designated/elected Offices, instead of, or in addition to, the translation of the claims as filed.

For further details on the requirements of each designated/elected Office, see Volume II of the PCT Applicant's Guide.

PATENT COOPERATION TREA

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
82		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/GB 99/ 04144	14/12/1999	17/12/1998

Applicant

CAMBRIDGE DISPLAY TECHNOLOGY LTD et al

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

 a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

 [] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

 b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

 [] contained in the international application in written form.

 [] filed together with the international application in computer readable form.

 [] furnished subsequently to this Authority in written form.

 [] furnished subsequently to this Authority in computer readble form.

 [] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

 [] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [] **Certain claims were found unsearchable** (See Box I).

3. [] **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,

 [X] the text is approved as submitted by the applicant.

 [] the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

 [X] the text is approved as submitted by the applicant.

 [] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the drawings to be published with the abstract is Figure No. 1

 [X] as suggested by the applicant.

 [] None of the figures.

 [] because the applicant failed to suggest a figure.

 [] because this figure better characterizes the invention.

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09/868262
PCT/GB99/04144
WO 00/36661
JC03 Rec'd PCT/PTC 15 JUN 2001

CLAIMS

1. An organic light-emitting device comprising a layer of light-emissive organic material interposed between a first electrode and a second electrode, at least one of the first and second electrodes comprising one or more electrode layers on the layer of light-emissive organic material for injecting charge carriers into the light-emissive organic material, wherein the organic light-emitting device further comprises a layer of dielectric material on the surface of the outermost electrode layer remote from the layer of light-emissive organic material .
2. An organic light-emitting device according to claim 1 wherein the dielectric material is selected from the group consisting of SiO, AlN, SiO_2, Si_3N_4 and Al_2O_3.
3. An organic light-emitting device according to claim 2 wherein the dielectric material is AlN.
4. An organic light-emitting device according to any preceding claim, wherein the thickness of the dielectric layer is in the range of 0.01 to 10 microns.
5. An organic light-emitting device according to claim 1 further comprising at least a second layer of dielectric material on the first layer of dielectric material, the thickness of the layers being selected so as to reduce mechanical stress on the cathode.
6. An organic light-emitting device according to claim 5 wherein the first and second layers of dielectric material comprise layers of different dielectric materials.
7. An organic light-emitting device according to claim 5 or claim 6 wherein the first and second layers of dielectric material comprise layers of materials selected from the group consisting of AlN, SiO_2, Si_3N_4 and Al_2O_3.
8. An organic light emitting device according to claim 5 wherein the first layer of dielectric material is a layer of AlN and the second layer of dielectric material is a layer of Al_2O_3.

9. An organic light-emitting device according to any of claims 5 to 8 wherein the first and second layers of dielectric material each have thicknesses in the range of 0.01 to 10 microns

10. An organic light emitting device comprising at least one layer of a light-emissive organic material interposed between a first electrode and a second electrode, at least one of the first and second electrodes comprising one or more electrode layers on the light-emissive material for injecting charge carriers into the light-emissive material; wherein the organic light-emitting device further has a stack comprising a first inert barrier layer and at least one gettering layer interposed between the outermost electrode layer and the first inert barrier layer for absorbing moisture and oxygen.

11. An organic light-emitting device according to claim 10 wherein the first inert barrier layer is a layer of a material selected from the group consisting of AlN, Al_2O_3, SiO_2 and Si_3N_4, and is preferably a layer of AlN.

12. An organic light-emitting device according to claim 10 wherein the first inert barrier layer has a thickness in the range of 0.01 to 10 microns.

13. An organic light-emitting device according to claim 1 wherein the stack further comprises a second inert barrier layer interposed between the gettering layer and the surface of the outermost electrode layer remote from the layer of light-emissive organic material.

14. An organic light-emitting device according to claim 13 wherein the second inert barrier layer is a layer of sputtered aluminium and the first inert barrier layer is a layer of AlN.

15. An organic light-emitting device according to claim 13 wherein the first and second inert barrier layers each have a thickness in the range of 0.01 to 10 microns.

16. An organic light-emitting device according to any of claims 10 to 15 wherein the gettering layer is a layer of a reactive metal or metal alloy, or a hygroscopic oxide.

17. An organic light-emitting device according to claim 16 wherein the gettering layer is a layer of BaO.

18. An organic light-emitting device according to claim 16 wherein the gettering layer is a layer of a material selected from the group consisting of Li, Ca, LiAl, Ba and Cs.

19. An organic light-emitting device according to claim 18 wherein the gettering layer is a layer of Ca.

20. An organic light-emitting device according to any of claims 10 to 19 wherein the thickness of the gettering layer is in the range of 0.01 to 5 microns.

21. An organic light emitting device according to claim 10 wherein at least one of the first and second electrodes is a multi-layered electrode comprising a first low work function conductive layer on the layer of light-emissive organic material and a second conductive layer on the surface of the first low work function conductive layer remote from the layer of light-emissive organic material.

22. An organic light-emitting device according to claim 21 wherein the first low work function conductive layer is an evaporated layer of calcium having a thickness of 200nm or less, and the second conductive layer is a layer of evaporated aluminium having a thickness of 5 microns or less.

23. A method of providing a protective cap on a first electrode of an organic light-emitting device comprising at least one layer of a light-emissive organic material between first and second electrodes for injecting charge carriers into the light-emissive organic material, said method comprising the step of forming a first layer of a dielectric material on the surface of the first electrode opposite the layer of light-emissive organic material by a vacuum evaporation technique.

24. A method according to claim 23 further comprising the step of forming a second layer of a dielectric material on the surface of the first layer of the dielectric material opposite the first electrode.

25. A method according to claim 23 or claim 24 wherein the first layer of dielectric material comprises a layer of silicon monoxide.

26. A method according to any of claims 23 to 25 wherein the first layer of dielectric material has a thickness in the range of 10 to 10,000 Angstroms.

27. A method according to claim 26 wherein the first layer of dielectric material has a thickness in the range of 100 to 2000 Angstroms.

28. A method according to claim 27 wherein the first layer of dielectric material has a thickness in the range of about 1000 Angstroms.

29. A method according to claim 24 wherein the second layer of dielectric material is formed by a sputtering technique.

30. A method according to claim 24 wherein the second layer of dielectric material comprises a layer of a material selected from the group consisting of AlN, SiO_2, Si_3N_4 and Al_2O_3.

31. An organic light-emitting device produced by a method according to any one of claims 23 to 30 claim 23

32. An organic light-emitting device substantially as hereinbefore described with reference to the accompanying drawings. Delete

ORGANIC LIGHT-EMITTING DEVICES

This invention relates to organic light-emitting devices (OLEDs).

Organic light-emitting devices such as described in US Patent No. 5,247,190 or in US Patent No. 4,539,507, the contents of which are incorporated herein by reference, have great potential for use in various display applications. According to one method, an OLED is fabricated by coating a glass or plastic substrate with a transparent first electrode (anode) such as indium tin oxide (ITO). At least one layer of a thin film of an electroluminescent organic material is then deposited prior to a final layer which is a film of a second electrode (cathode) which is typically a metal or alloy.

From the point of view of electron-injecting properties, a layer of a metal having a low work function such as calcium or an alloy containing a metal having a low work function are the preferred materials for the cathode. However, it is an intrinsic property of such low work function elements that they are very prone to reactions with reactive ambient species such as oxygen or moisture. Such reactions detrimentally affect the electron-injecting properties of the cathode causing the formation of non-emitting black spots with a consequent degradation in device performance.

It is therefore an aim of the present invention to provide an organic light-emitting device which is less prone to the formation of non-emitting black spots and therefore displays improved resistance to performance degradation.

It is another aim of the present invention to provide a method of producing a protective cap for an electrode of an organic light-emissive device which minimizes damage to the underlying organic layers.

According to one aspect of the present invention, there is provided an organic light-emitting device comprising at least one layer of a light-emissive organic material interposed between a first electrode and a second electrode, at least one of the first and second electrodes comprising one or more electrode layers on the

light-emissive material; wherein the organic light-emitting device further has a stack comprising an inert barrier layer and at least one gettering layer interposed between the outermost electrode layer and the inert barrier layer for absorbing moisture and oxygen.

The advantages of this aspect of the present invention are particularly pronounced when the electrode upon which the stack is formed comprises at least one layer deposited by vacuum evaporation.

The inert barrier layer serves to minimize the entry of reactive species into the device, and the gettering layer serves to absorb any traces of reactive species which manage to somehow permeate through the inert barrier layer.

The inert barrier layer is preferably a layer of an inorganic dielectric material preferably selected from the group consisting of AlN, Al_2O_3, SiO_2 and Si_3N_4, and preferably has a thickness in the range of 0.01 to 10 microns, further preferably in the range of 1 to 10 microns. The inert barrier layer is preferably deposited by a sputtering technique to provide a pinhole-free layer.

The gettering layer is preferably a layer of a material which displays high reactivity towards moisture and oxygen such as Li, Ca, Ba or Cs, or an alloy of the same such as LiAl, or a hygroscopic oxide such as BaO. It preferably has a thickness in the range of 0.01 to 5 microns. Calcium is a particularly preferred material for the gettering layer. The gettering layer may be deposited by a sputtering technique to provide a pinhole-free layer. Alternatively, it may be deposited by a vacuum evaporation technique.

According to another aspect of the present invention, there is provided an organic light-emitting device comprising a layer of light-emissive organic material interposed between a first electrode and a second electrode, at least one of the first and second electrodes comprising one or more electrode layers on the layer of light-emissive organic material for injecting charge carriers into the light-emissive organic material, wherein the organic light-emitting device further comprises a

layer of dielectric material on the surface of the outermost electrode layer remote from the layer of light-emissive organic material.

The advantages of this aspect of the present invention are also particularly pronounced when the electrode upon which the dielectric layer or layers is formed comprises at least one layer deposited by vacuum evaporation.

In one embodiment of the present invention, the organic light-emitting device further comprises a second layer of dielectric material on the first layer of dielectric material, the thickness of the dielectric layers being selected so as to reduce mechanical stress on the electrode .

Suitable dielectric materials for each of the first and second layers include inorganic dielectric materials, preferably SiO, AlN, SiO_2, Si_3N_4 and Al_2O_3. The thickness of each of the dielectric layers is preferably in the range of 0.01 to 10 microns, preferably in the range of 1 to 10 microns.

Each of the dielectric layers may be deposited by a sputtering technique or by a vacuum evaporation technique..

According to a third aspect of the present invention, there is provided a method of providing a protective cap on a first electrode of an organic light-emitting device comprising at least one layer of a light-emissive organic material between first and second electrodes for injecting charge carriers into the light-emissive organic material, said method comprising the step of forming a first layer of a dielectric material on the surface of the first electrode opposite the layer of light-emissive organic material by a vacuum evaporation technique.

The first electrode typically comprises one or more metal layers with the dielectric layer being formed directly on the surface of the outermost metal layer remote from the organic light-emissive material.

Further barrier layers and/or gettering layers of the kind discussed above can be provided on the first dielectric layer.

As with the first and second aspects of the present invention, the advantages of the third aspect of the present invention are pronounced when the subject electrode has been deposited by a vacuum evaporation technique.

Hereunder, preferred embodiments of the present invention will be described, by way of example only, with reference to the accompanying drawings in which:-

Figure 1 is a schematic cross-sectional view of an organic light-emitting device according to a first embodiment of the present invention.

Figure 2 is a schematic cross-sectional view of an organic light-emitting device according to a second embodiment of the present invention.

Figure 3 is a schematic cross-sectional view of an organic light-emitting device according to a third embodiment of the present invention.

Figure 4 is a schematic cross-sectional view of an organic light-emitting device according to a fourth embodiment of the present invention.

Figure 5 is a schematic cross-sectional view of an organic light-emitting device according to a fifth embodiment of the present invention.

Figure 6 is a schematic cross-sectional view of an organic light-emitting device according to a sixth embodiment of the present invention.

Figure 7 is a schematic cross-sectional view of an organic light-emitting device according to a seventh embodiment of the present invention.

An organic light-emitting device according to a first embodiment of the present invention is shown in Figure 1. The device comprises a first electrode layer 4, in this case an anode layer comprised of indium tin oxide (ITO) formed on a substrate 2. The substrate may, for example, be one made of glass or a flexible plastic substrate or may be a glass-plastic laminate. A first thin film 6 of a light-emissive organic material (in this case, poly(phenylenevinylene) (PPV)) is formed on the ITO layer 4. This organic PPV layer can be formed by spin-coating a precursor to PPV in a suitable solvent onto the ITO layer and then heating the spin-coated layer to convert the precursor to the polymer PPV. A second thin film 8 of an organic material (such as MEH-PPV) is formed on the first thin film of light-emissive organic material 6. This second thin film 8 can, for example, be formed in the same general manner as the first thin film 6 of light-emissive organic material. The

second thin film of organic material may serve as a light-emissive layer or a charge transport layer or have some other purpose. Further light-emissive organic layers can be provided.

Alternatively, layer 6 could be a charge-transport layer such as polyethylenedioxythiophene doped with polystyrene sulphonic acid (PEDT:PSS), or polyaniline and the second thin film 8 may be the light-emissive layer such as a blend of 5% poly(2,7-(9,9-di-n-octylfluorene)-3,6-(benzothiadiazole) with 95% poly(2,7-(9,9-di-n-octylfluorene) (5F8BT), poly (2,7-(9,9-di-n-octylfluorene) (F8), poly(2,7-(9,9-di-n-octylfluorene)-(1,4-phenylene-((4-methylphenyl)imino)-1,4-phenylene-((4-methylphenyl)imino)-1,4-phenylene))/poly(2,7-(9,9-di-n-octylfluorene) (PFM:F8), poly(2,7-(9,9-di-n-octylfluorene)-(1,4-phenylene-((4-methoxyphenyl)imino)-1,4-phenylene-((4-methoxyphenyl)imino)-1,4-phenylene))/poly(2,7-(9,9-di-n-octylfluorene)/poly(2,7-(9,9-di-n-octylfluorene)-(1,4-phenylene-((1,4-phenylene-((4-secbutylphenyl)imino)-1,4-phenylene)) (PFMO:F8:TFB).

A thin layer 10 of calcium having a thickness of 200nm is formed on the second thin film of organic material 8. This calcium layer functions as a cathode and can be formed, for example, by rf sputtering or dc magnetron sputtering (preferably using neon as a discharge gas) or by vacuum evaporation. Vacuum evaporation is the preferred technique because it causes less damage to the underlying organic material than a sputtering technique.

A thick layer of aluminium nitride 12 having a thickness of about 10 microns is formed on the thin layer of calcium 10. This aluminium nitride layer is preferably deposited by sputtering to provide a pinhole-free layer. A conventional sputtering technique such as rf sputtering or dc magnetron sputtering may be employed using a sputter target/cathode made of aluminium and a discharge gas containing nitrogen.

This thick aluminium nitride layer 12 is very impermeable with respect to ambient species such as oxygen and moisture and therefore serves to effectively protect the underlying calcium cathode layer from these reactive species.

An organic light-emitting device according to a second embodiment of the present invention is shown in Figure 2. It is identical to the device shown in Figure 1 except that an additional layer 14 of aluminium having a thickness of 5 microns is provided between the thin calcium layer 10 and the thick layer of aluminium nitride 12 as a second cathode layer. In this case, this intermediate layer of aluminium is formed by vacuum evaporation, but it could alternatively be formed by a sputtering technique for example.

An organic light-emitting device according to a third embodiment of the present invention is shown in Figure 3. It is similar to the device shown in Figure 2 except that a thick layer 16 of aluminium oxide having a thickness of about 10 microns is provided on the thick layer of aluminium nitride 12. This top layer of aluminium oxide is preferably formed by a sputtering technique in order to provide a pinhole-free layer.

An organic light-emitting device according to a fourth embodiment of the present invention is shown in Figure 4. This device is identical to that shown in Figure 2 except that a second layer of calcium 18 having a thickness of about 5 microns is provided between the aluminium layer 14 and the aluminium nitride layer 12. This second calcium layer is provided to getter any reactive species which may somehow manage to permeate through the overlying aluminium nitride and thus provide protection for the underlying cathode. This second layer of calcium 18 is preferably deposited by a sputtering technique in order to provide a pinhole-free layer.

An organic light-emitting device according to a fifth embodiment of the present invention is shown in Figure 5. This device is similar to that shown in Figure 4 except that a sputtered layer of aluminium 20 having a thickness of about 10 microns is provided between the evaporated aluminium layer 14 and the second layer of calcium 18 as an additional barrier layer. According to a further variation as shown in Figure 6, a further sputtered layer of aluminium is provided between the second calcium layer 18 and the aluminium nitride layer 12.

An organic light-emissive device according to a seventh embodiment of the present invention is shown in Figure 7. This is similar to the device shown in Figure 3, except that the Ca/Al two-layer cathode is capped with a 1000 Angstrom layer 24 of SiO deposited by thermal evaporation from a high temperature ceramic boat and a 10 micron layer 26 of aluminium nitride deposited by sputtering. The protective SiO/AlN two-layer cap employed in this embodiment provides excellent cathode protection. It is thought that this is due to the fact that the SiO layer not only acts as a physical barrier but also acts as a gettering layer by reacting with moisture.

Although, the devices described above all demonstrate the application of the present invention to the protection of a cathode, the present invention can equally be applied to the protection of the anode, or both the anode and the cathode.

CLAIMS

1. An organic light-emitting device comprising a layer of light-emissive organic material interposed between a first electrode and a second electrode, at least one of the first and second electrodes comprising one or more electrode layers on the layer of light-emissive organic material for injecting charge carriers into the light-emissive organic material, wherein the organic light-emitting device further comprises a layer of dielectric material on the surface of the outermost electrode layer remote from the layer of light-emissive organic material .
2. An organic light-emitting device according to claim 1 wherein the dielectric material is selected from the group consisting of SiO, AlN, SiO_2, Si_3N_4 and Al_2O_3.
3. An organic light-emitting device according to claim 2 wherein the dielectric material is AlN.
4. An organic light-emitting device according to any preceding claim, wherein the thickness of the dielectric layer is in the range of 0.01 to 10 microns.
5. An organic light-emitting device according to claim 1 further comprising at least a second layer of dielectric material on the first layer of dielectric material, the thickness of the layers being selected so as to reduce mechanical stress on the cathode.
6. An organic light-emitting device according to claim 5 wherein the first and second layers of dielectric material comprise layers of different dielectric materials.
7. An organic light-emitting device according to claim 5 or claim 6 wherein the first and second layers of dielectric material comprise layers of materials selected from the group consisting of AlN, SiO_2, Si_3N_4 and Al_2O_3.
8. An organic light emitting device according to claim 5 wherein the first layer of dielectric material is a layer of AlN and the second layer of dielectric material is a layer of Al_2O_3.

9. An organic light-emitting device according any of claims 5 to 8 wherein the first and second layers of dielectric material each have thicknesses in the range of 0.01 to 10 microns

10. An organic light emitting device comprising at least one layer of a light-emissive organic material interposed between a first electrode and a second electrode, at least one of the first and second electrodes comprising one or more electrode layers on the light-emissive material for injecting charge carriers into the light-emissive material; wherein the organic light-emitting device further has a stack comprising a first inert barrier layer and at least one gettering layer interposed between the outermost electrode layer and the first inert barrier layer for absorbing moisture and oxygen.

11. An organic light-emitting device according to claim 10 wherein the first inert barrier layer is a layer of a material selected from the group consisting of AlN, Al_2O_3, SiO_2 and Si_3N_4, and is preferably a layer of AlN.

12. An organic light-emitting device according to claim 10 wherein the first inert barrier layer has a thickness in the range of 0.01 to 10 microns.

13. An organic light-emitting device according to claim 1 wherein the stack further comprises a second inert barrier layer interposed between the gettering layer and the surface of the outermost electrode layer remote from the layer of light-emissive organic material.

14. An organic light-emitting device according to claim 13 wherein the second inert barrier layer is a layer of sputtered aluminium and the first inert barrier layer is a layer of AlN.

15. An organic light-emitting device according to claim 13 wherein the first and second inert barrier layers each have a thickness in the range of 0.01 to 10 microns.

16. An organic light-emitting device according to any of claims 10 to 15 wherein the gettering layer is a layer of a reactive metal or metal alloy, or a hygroscopic oxide.

17. An organic light-emitting device according to claim 16 wherein the gettering layer is a layer of BaO.

18. An organic light-emitting device according to claim 16 wherein the gettering layer is a layer of a material selected from the group consisting of Li, Ca, LiAl, Ba and Cs.

19. An organic light-emitting device according to claim 18 wherein the gettering layer is a layer of Ca.

20. An organic light-emitting device according to any of claims 10 to 19 wherein the thickness of the gettering layer is in the range of 0.01 to 5 microns.

21. An organic light emitting device according to claim 10 wherein at least one of the first and second electrodes is a multi-layered electrode comprising a first low work function conductive layer on the layer of light-emissive organic material and a second conductive layer on the surface of the first low work function conductive layer remote from the layer of light-emissive organic material.

22. An organic light-emitting device according to claim 21 wherein the first low work function conductive layer is an evaporated layer of calcium having a thickness of 200nm or less, and the second conductive layer is a layer of evaporated aluminium having a thickness of 5 microns or less.

23. A method of providing a protective cap on a first electrode of an organic light-emitting device comprising at least one layer of a light-emissive organic material between first and second electrodes for injecting charge carriers into the light-emissive organic material, said method comprising the step of forming a first layer of a dielectric material on the surface of the first electrode opposite the layer of light-emissive organic material by a vacuum evaporation technique.

24. A method according to claim 23 further comprising the step of forming a second layer of a dielectric material on the surface of the first layer of the dielectric material opposite the first electrode.

25. A method according to claim 23 or claim 24 wherein the first layer of dielectric material comprises a layer of silicon monoxide.

26. A method according to any of claims 23 to 25 wherein the first layer of dielectric material has a thickness in the range of 10 to 10,000 Angstroms.

27. A method according to claim 26 wherein the first layer of dielectric material has a thickness in the range of 100 to 2000 Angstroms.

28. A method according to claim 27 wherein the first layer of dielectric material has a thickness in the range of about 1000 Angstroms.

29. A method according to claim 24 wherein the second layer of dielectric material is formed by a sputtering technique.

30. A method according to claim 24 wherein the second layer of dielectric material comprises a layer of a material selected from the group consisting of AlN, SiO_2, Si_3N_4 and Al_2O_3.

31. An organic light-emitting device produced by a method according to any one of claims 23 to 30.

32. An organic light-emitting device substantially as hereinbefore described with reference to the accompanying drawings.

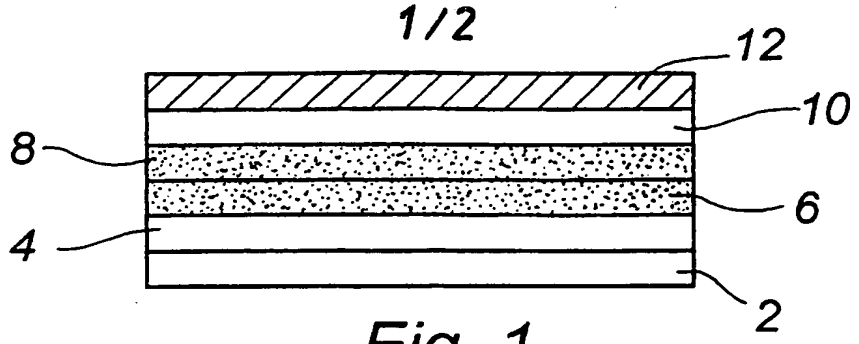


Fig. 1

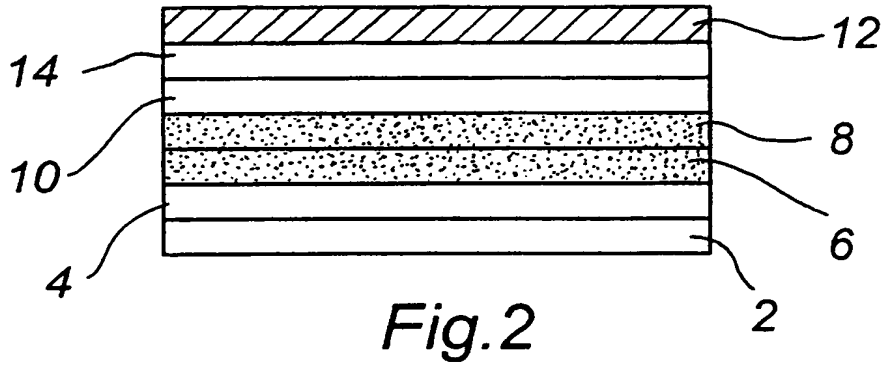


Fig.2

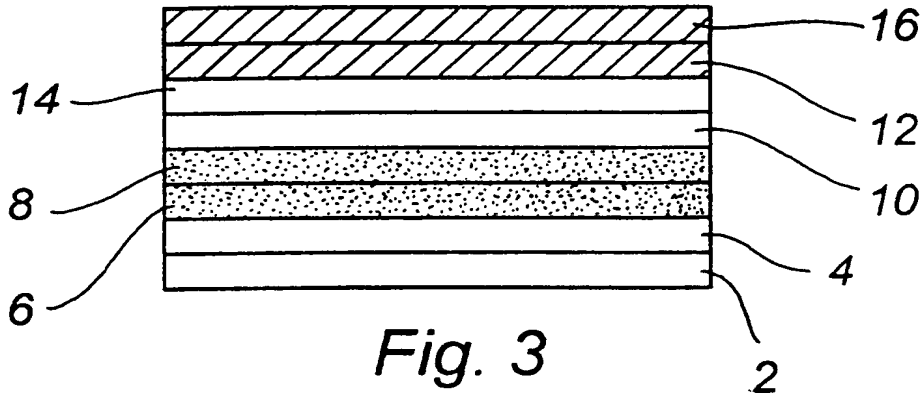


Fig. 3

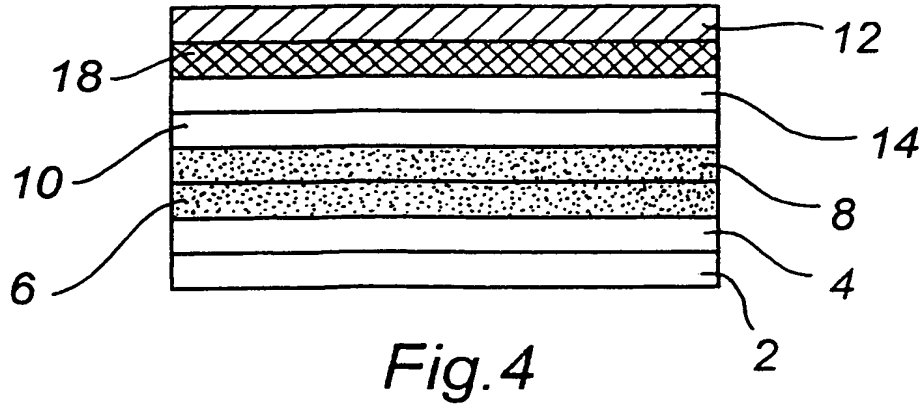


Fig.4

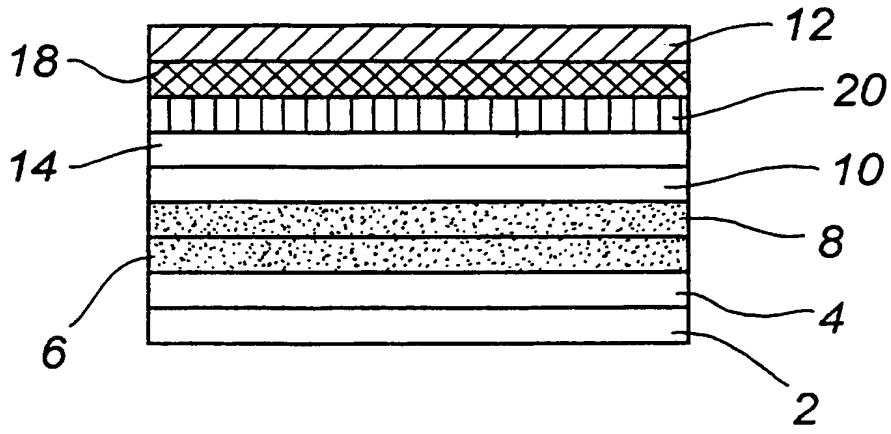


Fig. 5

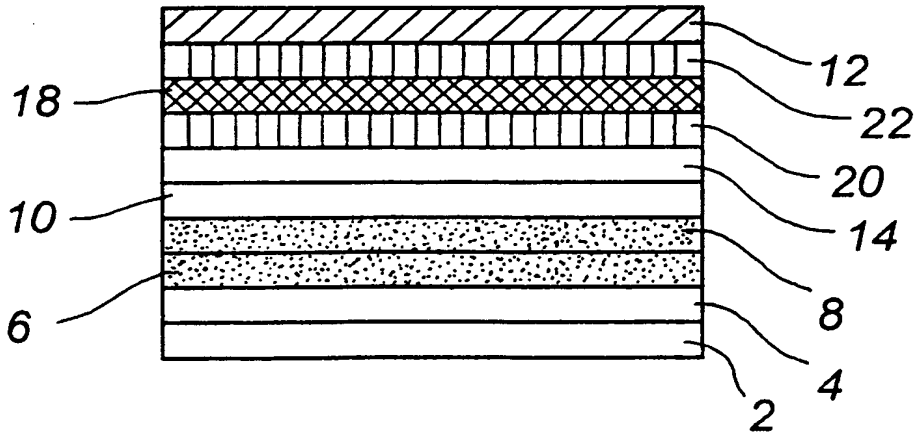


Fig. 6

INTERNATIONAL SEARCH REPORT

Intern. Application No
PCT/GB 99/04144

A. CLASSIFICATION F SUBJECT MATTER
IPC 7 H01L51/20

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A		2,3
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[X] Further documents are listed in the continuation of box C.

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8 March 2000	15/03/2000

Name and mailing address of the ISA	Authorized officer
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